make up water is recirculated through the heat exchanger. The make up water is added to compensate for the same loss modes mentioned above.

[0010] 5. Water is evaporated on the surface of the heat exchanger containing the medium to be cooled, and ambient air is also forced over the heat exchanger. The heat exchanger is covered with a water absorptive material. The amount of water sprayed on the heat exchanger is completely evaporated in cooling the medium to be cooled. No liquid water leaves the heat exchanger.

[0011] 6. This method is in accordance with the present invention, and is not to be considered prior art. Water is evaporated on the surface of the heat exchanger containing the medium to be cooled, and ambient air is forced over the heat exchanger. Water evaporates in the ambient air, cooling the medium inside the heat exchanger. The heat exchanger is covered with a water absorptive material. The amount of water deposited or sprayed on the evaporator is equal to the sum of the water that is evaporated to cool the medium inside heat exchanger, and the ~~water that is lost to the air stream~~ <u>excess water that leaves the heat exchanger</u>.

[0012] Excess water that leaves a heat exchanger without being evaporated carries concentrated dissolved substances away from the heat exchanger surface.

[0013] As noted, air at 35° C (95° F) dry bulb temperature and 23.89° C (75° F) wet bulb temperature may be expected to have a refrigerant condensing temperature of 51.67° C (125° F), in air only, using the method described in paragraph 1 above. Whereas water cooled and evaporative cooled equipment described in paragraphs 2 through 5, using the same air may be expected to have a refrigerant condensing temperature of 40.56° C (105° F). The Carnot cycle of the paragraph 6 method is depicted as 1a,2a,3a,4a in Figure 1, for a condensing temperature of 100° F, noticeably lower than for the other methods.

[0014] The method described in paragraph 1 also requires larger amount of air drawn over the heat transfer surface to carry the heat away, compared with that required in applications described in paragraphs 2 through 6. However, using water to cool in a once through system as described in paragraph 2 requires a large amount of water to be wasted. The cooling tower and recirculation described in paragraph 3 requires additional pumping capacity, additional fan capacity, and considerable maintenance (in terms of chemical additives and physical cleaning) to avoid formation of algae or other microorganisms and to avoid formation of scales. Scale reduces the heat transfer efficiency, or cause corrosion of the heat exchanger. Evaporative condensing as described in paragraph 4 eliminates the need for another device like a cooling tower while achieving temperatures in the medium to be

for another device like a cooling tower while achieving temperatures in the medium to be cooled comparable to those obtained by using recirculated water. However, conventional

Detailed Description of Examples of the Invention

[0035] Figure 1 shows the enthalpy and pressure during the Carnot cycle for a typically used refrigerant gas, R-22, in a compressor/evaporator/condenser arrangement that is used in refrigerators, chillers, air conditioners, and heat pumps. The various portion of the cycle pertinent to the present invention visible in Figure 1 are referred to in the following text as conditions 1a, 2a, 3a, and 4a.

[0036] Figures 2A, 2B and 3 show a heat rejecter such as a condenser with a multiplicity of coils 105 and 110 of metal tube 106, such as copper. The tube has an absorbent covering 107 (fig. 3) , which may be impregnated with an anti-microbial substance. The condenser coils 105 and 110 are in the form of a spiral so that the water deposited on the top of the tube will drip down to the tube course or rung below or will travel along the absorptive material spirally, until it reaches the bottom of the coil and finally drops into the water collection pan 410.

[0037] A tube 115 from the compressor ~~210~~ 205 discharges refrigerant gas at condition 2a into the condenser coils 105 and 110. The refrigerant passes downwardly through the coils and gradually converts into the liquid form at condition 3a. At the end of the coils, it deposits into a liquid refrigerant tube 120. The liquid refrigerant then passes through a filter and drier 125 into the liquid line 130, which is connected to a conventional expansion valve (not shown). Liquid refrigerant then passes through the expansion valve into the evaporator coil at condition 4a. It is then sucked in by compressor 205 through inlet 225, at the condition 1a.

[0038] The top portion of the compressor 205 is covered by an absorptive material 210 (like covering 107 and preferably impregnated with anti-microbial substance) that extends as far as water collection ring 215. Water collection ring 215 is located at a height above which, the hot discharge gases come in contact with the exterior of the compressor. Water overflow tube 220 takes excess water from the ring 215 to the bottom of the compressor so that the water does not touch normally cooler parts of the compressor and heat up the suction gas inside that portion of the compressor 205. Compressor 205 is attached to the hat channels 235 and 240 by isolation package 230. Ends of the hat channels 235, and 240, are attached to vertical support channels 250, 255 (and others, not shown), to keep it off the floor. These rest on angles 270 on floor, and provide room for drain connection from collection pan 410.

which the water is evaporated to cool refrigerant. For hot, dry climates like Arizona, evaporation ~~proceeds faster~~ <u>requires more water</u> than in humid climates.

[0044] Water supplies almost invariably have dissolved solids, but the type and concentration of the dissolved solids varies by geography. The accumulation of these solids can lead to deposits being formed in the equipment, which can inhibit its thermal transfer efficiency and ultimately may lead to system failure. One manufacturer of recirculating systems recommends that solids be limited as set forth in Table 1:

TABLE 1

	G210 Galvanized Steel	Stainless Steel (Optional)
PH	7 to 9.0	6.5 to 9.0
Hardness as $CaCO_3$	500 PPM MAX	500 PPM MAX
Alkalinity as $CaCO_3$	500 PPM MAX	500 PPM MAX
Total Dissolved Solids	1500 PPM MAX	2000 PPM MAX
Chlorides As NaCl	750 PPM MAX	1500 PPM MAX
Sulfates	500 PPM MAX	750 PPM MAX

[0045] Thus, the dissolved solids in the water supply are also taken into account in determining the desired water application rate.

[0046] The concept of cycles of concentration is commonly used in industrial/commercial cooling tower operation. As pure water is evaporated, minerals are left behind in the recirculating water. As evaporation continues, the water becomes more concentrated than the original make up water. This eventually can lead to saturated conditions. The term "cycles of concentration" compares the level of solids of the recirculating cooling tower to the level of solids of the original raw make up water. If the circulating water has four times the solids concentration than that of the make up water, then the cycles are 4. This concentration (or greater) continually passes over the entire coil.

[0047] Although the present invention does not involve recirculation, a similar nomenclature can be used. That is, the ratio of the solids concentration in the discharged water to the concentration in the applied water is herein referred to as the "cycles of concentration." Typically, the greater the applied water rate, the greater the discharged water rate, and the lower the cycles of concentration. In most instances the goal will be to apply enough water to keep the cycles of concentration low enough to prevent scale formation, but

E, should be very reduced. When there is no call for cooling, (calls for cooling usually are signals from a thermostat) solenoid valve 315 is closed. The solenoid valve 355 is then opened if the time interval for which there was no cooling demand is less than adjustable set point T1 (see Figure 4). Otherwise the valve 355 is turned on adjustable time T2 less than the time there was no call for cooling the previous time. Valve 355, when energized, delivers water through the alternate tube 360, through alternate distributor 365 and controlled water distributing devices 375 and tubes 380 to the coils 105 and 110. This minimizes the likelihood that the absorptive material will become completely dry, avoiding excessive build up of contaminant dissolved solids on the coils 105 and 110.

[0055] The expected cycles of concentration performance for the preferred embodiment per ton of cooling capacity for various water application rates is set forth in Table 2:

TABLE 2

Desired Cycles of concentration at the bottom of the entire column of coil	2.000	2.500	3.000	4.000	5.000	6.000	7.000	8.000
Water applied (GPH/ton)	3.00	2.50	2.25	2.00	1.88	1.80	1.75	1.71
Bleed to drain at the bottom (GPH/ton)	1.5	1	0.75	0.5	0.375	0.3	0.25	0.2143
Evaporation (GPH/ton)	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
At first 25% length segment	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Evaporation (GPH/ton)	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375
Bleed to next portion below (GPH/ton)	2.625	2.125	1.875	1.625	1.500	1.425	1.375	1.339
Cycles of concentration at segment end	1.143	1.176	1.200	1.231	1.250	1.263	1.273	1.280
At second 25% length segment	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Evaporation (GPH/ton)	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
Bleed to next portion below (GPH/ton)	2.250	1.750	1.500	1.250	1.125	1.050	1.000	0.964
Cycles of concentration at segment end	1.333	1.429	1.500	1.600	1.667	1.714	1.750	1.778
At third 25% length segment	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Evaporation (GPH/ton)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Bleed to next portion below (GPH/ton)	1.875	1.375	1.125	0.875	0.750	0.675	0.625	0.589
Cycles of concentration at segment end	1.600	1.818	2.000	2.286	2.500	2.667	2.800	2.909
Cycles of concentration at end	2.000	2.500	3.000	4.000	5.000	6.000	7.000	8.000

[0056] In an alternate embodiment controller 405 monitors the water flow rate through the device 420, and controls a single variable flow water valve to maintain the water flow based on pre-determined level arrived at by such operational factors as, whether the